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This report describes the use of several personnel flow models as applied to anticipated large scale work force changes in U. S. Navy shipyards. The first applications show how simple personnel flow models can be developed using spreadsheet software or a microcomputer. The final application shows the use of a mainframe based "flexible" flow model to include the effects of internal staffing decisions.

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RESEARCH REPORT NO. 46

USE OF PERSONNEL FLOW MODELS
FOR ANALYSIS OF LARGE SCALE WORK FORCE CHANGES

by

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FEBRUARY 1986

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WASHINGTON, D.C. 20350

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FORWARD

Research Report No. 46 was prepared as part of the activities of
the Assistant for Human Resources Analysis (OP-16H). The report
describes the use of several personnel flow models as applied to
anticipated large scale work force changes in the U.S. Navy
shipyards. The applications range from simple models using
spreadsheets on a microcomputer to more complex flexible flow
models developed on a mainframe computer.

This report is approved for public release.

RICHARD J. NIEHAUS
Assistant for Human
Resources Analysis (OP-16H)

I. INTRODUCTION

The fundamental development of personnel flow models was completed and extensively reported in the literature in the 1970's. Developments since then include implementation of simple forms of these models on microcomputers. Specialized extensions have also been developed which permit analysis of "flexible" personnel flows in connection with promotion and upward mobility planning and with rapidly changing projected work loads. This paper discusses applications both of these recent developments in an analysis of anticipated large scale work force changes in U.S. Navy shipyards. These eight shipyards under the management of the Naval Sea Systems Command (NAVSEA) employed approximately 76,000 workers in June 1985.

A review of the technology of computer-assisted personnel flow models can be found in Niehaus (1979, 1985). The first reference (1979) is a comprehensive monograph on the design of personnel flow and external labor market models including implementation considerations. The second reference (1985) describes current and projected applications of human resource policy analysis techniques in the 1980's. A useful case study concerning the implementation of personnel flow models in the IBM Corporation can be found in Heyer (1985).

The flexible flow model presented in this paper is an extension of the goal-arc distribution models originally developed by Charnes, Cooper, Lewis and Niehaus (1978) for affirmative action planning. An initial implementation of this model was completed by Charnes, Cooper, Nelson, and Niehaus

1

(1982). The model was tested operationally by Aiken, Nelson, Murphy, and Niehaus (1981). The basic model structure was further developed for U.S. Navy sea-shore rotation applications by Charnes, Cooper, Golnay, Lovegren, Mayfield, and Wolfe (1985).

This paper begins with a statement of the issues involved in required work force reductions at the shipyards. A discussion follows describing the models used in the initial applications. Results are then are shown from the preliminary model runs in an operational setting. Finally, a short review is provided of plans to continue this implementation effort in NAVSEA.

II. BACKGROUND

The work described in this paper was performed to assist NAVSEA managers in responding to a requirement to reduce the number of shipyard employees. In order to plan for the required employee reduction, it is necessary to be able to project the number of employees who can be expected to leave voluntarily. It is also useful to know the number expected to transfer from one occupation to another within a shipyard.

In the examples shown in this paper the initial work force populations are as of June 30, 1985. Table 1 shows the relative size of the planned reductions. Although the total reductions seem within range of losses expected through normal attrition, Shipyards B, E and H require reductions clearly exceeding expected losses. Further differences emerge at the occupation level. Personnel flows for these populations were projected by quarter, six month period, and year to the end of September 1987. This information can be used by NAVSEA managers at headquarters and in the individual shipyards to develop plans for hires and/or

2

PROJECTED SHIPYARD WORK FORCE REDUCTIONS

(CUMULATIVE PERCENT FROM JUNE 1985 ACTUAL)

	SEP 85	DEC 85	MAR 86	JUN 86	SEP 86	SEP 87
SHIPYARD A	-1.1	-1.7	-1.9	-2.1	-2.3	-2.3
SHIPYARD B	0	-15.5	-18.6	-21.6	-24.6	-26.4
SHIPYARD C	-1.6	-2.6	-3.3	-3.9	-4.6	-6.1
SHIPYARD D	-3	-4.9	-5.1	-5.4	-5.7	-4.5
SHIPYARD E	-6.8	-8.2	-7.4	-6.7	-6	-19.1
SHIPYARD F	0.3	-1.5	-6.7	-11.8	-17	-17.5
SHIPYARD G	1.4	-1.9	-1.1	-0.3	0.5	2.4
SHIPYARD H	-10.2	-10.9	-13.7	-16.6	-19.4	-34.6
TOTAL	-1.7	-4.5	-5.9	-7.4	-6.2	-12.7

PRELIMINARY

TABLE 1

3

reductions by skill categories to achieve overall reduction targets.

The first application shows how simple flow models can be quickly implemented to respond to rapidly developing policy changes. A spreadsheet version of a personnel flow model was first developed on a microcomputer (IBM PC/XT), using commercially available spreadsheet software (LOTUS 1-2-3). Personnel transition rates developed on a mainframe computer information system were downloaded to the microcomputer via telecommunications software and then entered into the spreadsheet. A second stage analysis extended the number of job categories and refined preliminary results.

Two types of projections are possible with the spreadsheet flow model. The first type is a simple flow model with normal attrition. This projection assumes that the work force is allowed to "run down" by normal attrition with no replacement. Movements among job categories are assumed to continue at the normal rates. The second type of projection includes work force goals for each occupational category for each of the five planning periods. Projected hires and reductions are calculated to exactly meet the goals for each occupational category at the end of each time period. Individual models are developed for each of the shipyards so that management decisions can be made where any personnel actions might need to be effected. Although these models were developed to respond to aggregate reductions specified at the corporate NAVSEA level, they can also be used to develop manpower requirements tied to internal shipyard planning consistent with overall NAVSEA ship overhaul scheduling.

Another prototype study was completed using a flexible flow model to balance work force levels and flows across time periods as well as among job categories. The planning periods were also modified to use time periods of unequal length to allow the integration of short and long term planning in the same model. In this case, as with the spreadsheet models, quarters are used for the most immediate time periods. Later time periods were of six month and year length. The flexible flow model results were developed for one of the shipyards to permit comparative analysis with the spreadsheet results.

The study is also being done to provide additional requirements information for the update and improvement of the Computer-Assisted Manpower Information System (CAMAS). This Navy-wide system, dating from the early 1970's, is being migrated to an IBM 3081 computer in two stages. The first stage is to establish a baseline system which will incorporate interactive batch processing. In this case the user will be able to interactively prepare menu screens which specify needed modeling and reporting outputs. Processing will be in a batch mode as best determined by overall mainframe loading. In the second stage, CAMAS will be improved to permit interactive processing where possible as well as using advanced information retreival methods such as relational data base software.

The next section of this paper will discuss the development of the input data used in the models, including the way that the job categories were developed. Following a general discussion of the methodologies used, results for each of the model types will

5

be provided. The actual data have been masked because of the
nature of the management decisions involved.

III. MODEL INPUT DATA

The flow models use data available from operational
information systems, internal reports, or simple estimates. The
data that are needed include: initial job category populations,
personnel movement or transition rates, manpower requirements,
and total manpower ceilings. The analysis used the Department of
the Navy's Computer-Assisted Manpower Analysis System (CAMAS) to
produce the initial job category population data and personnel
transition rates. CAMAS draws upon the Navy's Personnel
Automated Data System (PADS) for the basic personnel inventory
data. An existing historical data base of over ten years of
PADS data allows some smoothing of transition data developed for
use in the models. A more detailed description of the input data
characteristics is provided below.

a. Job Categories

A standardized Navy job category aggregation scheme is used
for analyses and reports developed from CAMAS and related
information systems. This job category aggregation scheme uses
the Department of Navy Occupation Level (DONOL) codes. In the
interests of time, the initial models were developed at the
highest level of DONOL occupational aggregation as shown in
Figure 1. Career or grade level distinctions were not addressed
in order to keep the outputs focused for the highest management
levels in NAVSEA.

Figure 1
Nine DONOL Major Occupation Groups

(1-Digit DONOL Codes)

1 ENGINEERING AND SCIENCE TECHNICIANS
2 SCIENTISTS AND ENGINEERS
3 OTHER PROFESSIONALS
4 MANAGEMENT AND ADMINISTRATION
5 OTHER TECHNICIANS
6 CLERICAL EMPLOYEES
7 OTHER GS EMPLOYEES
8 BLUE-COLLAR WORKERS
9 OPERATIONS AND SERVICE WORKERS

The initial model results were reviewed by NAVSEA top
management and staff. These NAVSEA executives felt that
additional detail was needed to highlight the blue-collar
work force, of particular concern in the management of shipyards.
In order to provide this additional detail but preserve a one
page summary report, a combination of DONOL occupation level
groupings was used. The white collar jobs were defined at the
one-digit DONOL code level while the blue collar jobs were
defined in greater detail at the two-digit DONOL code level.
This produced 18 job categories as shown in Figure 2. (Future
standardized CAMAS programs will permit this type of job category
combination from a menu screen.) As the shipyards have no
employees in the Aircraft Mechanic category, this category was
eliminated from the report.

b. Transition Rates

All of the projections in this paper are based a cross-
sectional or "snapshot" approach (Markov-like models), as

Figure 2
Eighteen Occupational Groups for Shipyard Projections

(compiled from 2-digit DONOL codes)

     1   ENGINEERING AND SCIENCE TECHNICIANS
     2   SCIENTISTS AND ENGINEERS
     3   OTHER PROFESSIONALS
     4   MANAGEMENT AND ADMINISTRATION
     5   OTHER TECHNICIANS
     6   CLERICAL EMPLOYEES
     7   OTHER GS EMPLOYEES
     8   ELECTRICAL MECHANICS
     9   ELECTRICIANS
    10   MACHINE TOOL OPERATORS
    11   METAL PROCESSORS
    12   METAL MECHANICS
    13   AIRCRAFT MECHANICS
    14   PIPEFITTERS
    15   WOODWORKERS
    16   PAINTERS
    17   MISCELLANEOUS CRAFT
    18   OPERATIONS AND SERVICE WORKERS

distinguished from the more complex longitudinal or "cohort" approaches and entity simulation methods. The projections assume that attrition and personnel flows between categories will continue at rates estimated from historical behavior. Using the eighteen categories indicated above, projections of personnel transition rates were developed for the preceding three years.

An example of the development of the transition rate data base is useful for those not familiar with the methodology. Figure 3 shows the type of information needed to develop the transition data. Each employee's job category is given for Time 1 and Time 2. Each change in employee category from Time 1 to Time 2 is added to a count of changes between specific categories. The resulting counts of personnel flows constitute the transition data, which are then divided by the number of employees beginning Time 1 in each category to yield the observed transition rates. (In CAMAS, separate files are kept for each time period and the transition rates are developed by a specially designed menu driven computer program.)

Figure 3
Transition Data File

EMPLOYEE NUMBER	JOB CATEGORY	
	TIME 1	TIME 2
1438	ENGINEER	ENGINEER
1524	TECHNICIAN	
2133	TECHNICIAN	ENGINEER
2619		TECHNICIAN

In Figure 3 it can be seen that Employee No. 1438 was an engineer in both time periods. On the other hand, Employee No.

9

1524 was a technician in period 1 but was not in the organization in period 2. Also, employee No. 2133 was promoted from technician to engineer between the two time periods. Finally, employee No. 2619 was hired during period 1. This kind of data can then be used to create a matrix such as provided in Figures 4 and 5. Figure 4 contains the actual counts. The transition rates in Figure 5 are obtained by dividing the movement data by the starting numbers. For example, 320/400 or 80% of the technicians remained technicians, 20/400 or 5% were promoted to engineer and 60/400 or 15% left the organization.

Figure 4
Personnel Movement Statistics

JOB CATEGORY	NUMBER YR 1	MOVEMENT TO TECHNICIAN	ENGINEER	LOSSES
TECHNICIAN	400	320	20	60
ENGINEER	200	6	180	14
	HIRES	94	5	
NUMBER YR 2		420	205	

Figure 5
Personnel Transition Rates

FROM	MOVEMENT TO TECHNICIAN	ENGINEER	LOSSES
TECHNICIAN	.80	.05	.15
ENGINEER	.03	.90	.07

By reading across the rows of Figures 4 and 5 one can see how a given job category changed from the start of the period. By reading down, one can see how a job category was built up over the time period. For projection purposes only the interior or

internal movements are used, since one can assume the remainder to have left the organization.

Each transition matrix used in the shipyard study is a weighted average of the data from the last three years. For example, the April-June transition matrix used in the projections is computed from the data for that quarter in 1983, 1984, and 1985. Data for these three years were given weights of 1, 2 and 3, respectively for the weighted average. That is, the final transition matrix was a composite of data using the 1983 data multiplied by one-sixth, the 1984 data multipled by one-third, and the 1985 data multiplied by one-half. Data from the most recent period were thus given the most weight in this average.

c. Initial Population Data

The initial population for each job category was obtained from CAMAS transition data files. These figures were then proportionately adjusted by the official on-board totals used for manpower ceiling control purposes. This minor adjustment insured that the the sum of the data by job category exactly equalled the official control totals.

d.   Manpower Requirements and Ceiling Data

Manpower requirements at the occupation level were not available for this study. These data were estimated by proportionally adjusting the initial population figures by the official manpower ceilings for the planning periods, obtained from NAVSEA planning documents. Since this adjustment was performed within the LOTUS 1-2-3 spreadsheet, any planned change in the ceiling numbers can be rapidly evaluated.

11

IV. MODEL RESULTS

The transition matrices for each shipyard were downloaded
onto a microcomputer (IBM PC/XT) and manually combined with the
other input data into a LOTUS 1-2-3 spreadsheet. Each
spreadsheet contains two different flow models based on the
following assumptions: (1) natural attrition with no hiring,
drawing down the work force over time and (2) a drawdown based on
reductions or hires as necessary to meet management targets as
set by NAVSEA. The two models use the same set of transition
matrices, which only has to be transferred once for each
spreadsheet. Data for one of the shipyards were also
subsequently used in the test of the flexible flow model on a
mainframe computer.

a. Simple Flow Models Without Replacement

This set of projections was based on estimated transition
rates alone, with no hiring or reductions. The purpose of these
projections was to show how the work force would evolve without
management intervention. To illustrate this process, we can
follow one row on Figure 6, which shows the results for a
representative shipyard. We select the row for scientists
and engineers. The entry on that row in the first column of
numbers shows that, as of June 30, 1985, there were 270
scientists and engineers actually on board. Starting from this
number, we then wish to project the number of scientists and
engineers on board on September 30, 1985.

Examination of the transition rates derived from the June-
September quarters for 1982, 1983, and 1984 (weighted 1,2 and 3,
respectively) indicates that there were three possible internal

12

OCCUPATIONAL PROJECTIONS (NO HIRING)

SHIPYARD B

	ACTUAL JUN 85	PROJECTED ON-BOARD				
		SEP 85	DEC 85	MAR 86	SEP 86	SEP 87
ENG & SCI TECH	386	370	370	370	343	315
SCI & ENG	270	249	243	233	208	174
OTHER PROF	25	23	21	21	18	15
MGR & ADMIN	280	268	265	261	242	217
OTHER TECH	209	202	192	187	177	154
CLERICAL	344	294	272	236	190	129
OTHER GS	7	5	5	3	2	1
ELEC MECH	328	310	306	290	263	231
ELECTRICIANS	549	500	481	459	408	342
MACH TOOL OP	420	410	401	382	363	324
METAL PROCESS	469	434	424	411	381	339
METAL MECH	774	723	693	668	611	539
PIPEFITTING	681	627	590	559	516	450
WOODWORKERS	201	189	184	179	167	150
PAINTERS	162	153	143	132	123	106
MISC CRAFT	951	897	836	758	695	600
OP & SVC WKRS	576	542	527	488	451	396
TOTAL	6632	6197	5953	5636	5161	4482

EXPERIMENTAL REPORT

FIGURE 6

13

sources of scientists and engineers during that quarter (i.e.,
nonzero transition rates): transfers from engineering and science
technicians, those remaining in the scientist and engineer
category from the previous period, and transfers from other GS
employees. The transition rates and initial on-boards for the
quarter are given in Figure 7:

Figure 7
Sources for Flows into Scientists and Engineers

SOURCE:	RATE	INITIAL ON-BOARDS	PROJECTED FLOW
SCI & ENG TECH	.0031	386	1
SCIENTISTS AND ENGINEERS	.9183	270	248
OTHER GS EMPLOYEES	.0214	7	0
TOTAL			249

Applying the transition rates to the initial on-boards, one
of the science and engineering technicians on board at the
beginning of the quarter enters the scientists and engineers
category during the quarter, 248 of the scientists and engineers
on board at the beginning of the quarter are still there at the
end and no other GS employee enters the scientists and engineers
category. The total for scientists and engineers in the new
quarter is then 249. The populations are then projected forward
one period at a time in the same fashion.

b. Simple Flow Models with Goals

The previous example shows that reliance on attrition alone
to reduce work force size leads to occupation imbalance. Due to
differences in loss rates across and among occupations, attrition

14

without replacement leads to an excess of employees in some occupations and a shortage in others. A second set of projections were made to also include hires and reductions needed to meet manpower requirements or goals.

This second set of projections used the same transition matrices as the prior case, but included management-determined goals at each stage of the process. The results provide the number of projected hires or reductions necessary to meet the goals. Figure 8 shows the model output for the test shipyard.

The model output can again be illustrated by following the corresponding line for scientists and engineers. As before, there were 270 employees actually on board in this category in June 1985. The goal for September 1985 is the same as the June 1985 on-boards, 270. As seen in the prior example, attrition alone would reduce the number on board to 249. The present example shows that 21 new employees would have to be hired in this category. This number is given in the increase (excess) column. Figure 8 shows that all goals are met. In this case, the required 21 scientists and engineers are hired.

During the September to December 1985 period the transition calculations indicate that there would a reduction in the scientist and engineer population from 270 to 264. Since the management goal for scientists and engineers for December 1985 is 228, a further reduction of 36 is required, as shown in Figure 8. Further examination indicates that additional hiring will be required in later time periods to meet scientist and engineer goals. Since this pattern of alternate hiring and reduction occurs frequently, the modeling approach was next extended to

OCCUPATIONAL PROJECTIONS(ON-BOARD TARGETS)

SHIPYARD B

	ACTUAL JUN 85	SEP 85	INCREASE (EXCESS)	DEC 85	INCREASE (EXCESS)	MAR 86	INCREASE (EXCESS)	SEP 86	INCREASE (EXCESS)	SEP 87	INCREASE (EXCESS)
ENG & SCI TECH	386	386	16	326	-61	314	-13	291	-3	284	13
SCI & ENG	270	270	21	228	-36	220	2	204	8	199	29
OTHER PROF	25	25	2	21	-2	20	0	19	1	18	2
MGR & ADMIN	280	280	12	236	-41	228	-5	211	-2	206	15
OTHER TECH	209	209	7	176	-23	170	-3	158	-6	154	11
CLERICAL	344	344	50	290	-28	280	29	259	35	253	80
OTHER GS	7	7	2	6	0	6	2	5	1	5	2
ELEC MECH	328	328	18	277	-47	267	4	247	5	241	23
ELECTRICIANS	549	549	49	464	-63	447	4	414	16	404	57
MACH TOOL OP	420	420	10	355	-56	342	3	317	-8	309	24
METAL PROCESS	469	469	35	396	-62	382	-1	354	-1	345	30
METAL MECH	774	773	50	654	-87	630	0	584	8	570	55
PIPEFITTING	681	680	53	575	-65	554	9	513	1	501	54
WOODWORKERS	201	201	12	170	-26	164	-1	152	-2	148	12
PAINTERS	162	162	9	137	-14	132	5	122	-1	119	14
MISC CRAFT	951	950	53	803	-83	774	46	717	9	700	83
OP & SVC WKRS	576	575	33	486	-74	469	19	434	-1	424	42
TOTAL	6632	6628		5600		5400		5000		4880	
TOTAL INCREASES			432		0		123		84		546
TOTAL (EXCESS)			0		-768		-23		-24		0

EXPERIMENTAL REPORT

FIGURE 8

16

include the possibility of smoothing the work force variations over time.

c. Flexible Flow Models

The simple flow model with goals shows the projected hires and reductions needed to meet the management goals exactly. A more complex model was next examined to allow variations from the goals to smooth work force flows across multiple time periods. This model also allows flexible flows among job categories to reduce the requirements for hires and reductions. The model uses the same inputs (initial on-boards, management-determined goals, and personnel transition rates) as the simple flow model with goals. Additional parameters in terms of relative priority weights among possible management decisions and upper and lower bounds on the goals are included to define the flexibility allowed.

The output of this model provides a one page report for each time period. An example of one page of the model output for the test shipyard is shown as Figure 9. The left side of the report shows the initial on-boards. The manpower requirements or goals, the projected final on-boards, and the deviation from the goals are shown on the right side. The intervening columns indicate the personnel actions which relate the initial on-boards to the final on-boards: hires, reductions, transfers in, transfers out, and other losses (attrition). Transfers in and transfers out are further disaggregated into expected transfers and flexible transfers. Expected transfers are the flows between job categories that would be expected without management intervention. Flexible transfers are the changes from the

17

DEPARTMENT OF THE NAVY
PROJECTED PERSONNEL ACTIONS FOR PERIOD 1
NAVSEA:
SHIPYARD B

MAJOR OCCUPATION AND CODE	LEV	INITIAL ON-BOARD	INCREASE	EXCESS	TRANSFERS IN EXP	FLEX	ACT	TRANSFERS OUT EXP	FLEX	ACT	OTHER LOSSES	FINAL ON-BOARD	GOAL	DEVIATION FROM GOAL
1 FNG & SCI TECH	1	386	0	0	0	0	9	3	2	5	22	368	386	-18
2 SCI & ENG	1	270	0	0	1	0	1	0	2	2	21	248	270	-22
3 OTHER PROF	1	25	0	0	0	0	0	0	1	1	1	23	25	-2
4 MGR & ADMIN	1	280	0	0	6	4	10	2	3	5	17	268	280	-12
5 OTHER TECH	1	209	0	0	8	-2	6	3	2	5	13	197	209	-12
6 CLERICAL	1	344	0	0	0	10	10	14	-10	4	38	312	344	-32
7 OTHER GS	1	7	1	0	0	0	0	0	0	0	1	7	7	0
8 ELEC MECH	1	328	0	0	0	2	2	0	2	2	17	311	328	-17
9 ELECTRICIANS	1	549	0	0	1	1	2	13	1	14	38	499	549	-50
10 MACH TOOL OP	1	420	0	0	5	3	8	5	1	6	12	410	420	-10
11 METAL PROCESS	1	469	0	0	2	1	3	0	0	0	36	436	469	-33
12 METAL MECH	1	774	0	0	6	4	10	4	1	5	54	725	773	-48
14 PIPEFITTING	1	681	0	0	1	1	2	5	3	8	49	626	680	-54
15 WOODWORKERS	1	201	0	0	4	1	5	0	1	1	15	190	201	-11
16 PAINTERS	1	162	0	0	1	1	2	0	2	2	10	152	162	-10
17 MISC CRAFT	1	951	0	0	17	0	17	5	2	7	66	895	950	-55
18 OP & SVC WKRS	1	576	0	0	19	-9	10	26	4	30	25	531	575	-44
TOTAL		6632	1	0	80	17	97	80	17	97	435	6198	6628	-430

EXPERIMENTAL REPORT

FIGURE 9

18

historical pattern that management might choose to improve work force balance without resorting to hires or reductions.

Unlike the previous model, this flexible flow model indicates essentially no hiring in the first time period and a final on-board total that is significantly below the sum of the goals (the end strength control total). The reason for this is that the goals in the next time periods are markedly lower. Hires in the first period would result in more reductions in later periods. The model projects declining on-boards that are above goals for December 1985 and March 1986. The projected on-boards are then at the end strength requirements until September 1987. These results suggest that the intermediate control totals might be adjusted to meet longer term end strength control totals through a mixture of attrition and reductions that results in less turbulence than indicated by the spreadsheet model results.

V. FURTHER NAVSEA APPLICATIONS

There has already been a complete update of the model results to reflect both the work force populations at the shipyards as of September 1985 and changes in the shipyard overhaul schedules. While the trends remain the same, individual shipyard loadings are already different from those in effect at the time the results shown in this paper were developed. Thus, the results should only be considered as illustrative of ways to use the personnel flow model technology.

The results from the personnel flow models were of use to NAVSEA in assessing the impacts of the large reductions required of the shipyards. The reports were used by NAVSEA headquarters to get a look ahead capability. The model results were also

19

provided to the individual shipyard commanders to begin a dialogue on more extensive use. Considering the trends in the Federal budget, it is anticipated that the problem of personnel reductions will continue to be an issue for the next few years. A quarterly tracking system has been instituted to review the accuracy of the projections and to provide a rolling projection to account for changing shipyard work loads.

Preliminary discussions have been held with individual shipyard planning staffs to determine the usefulness of the models to their efforts. It appears that the individual shipyard planners particularly prefer the spreadsheet models. They prefer to have personnel on-board when they are needed to minimize overhaul costs. On the other hand, the personnel staffs tend to like the flexible flow models since personnel turbulance is kept to a lower level and career planning and training can be included in the plans.

An area where further work is planned is in the development of better estimates of manpower requirements data. At the local level it would be useful to feed the manpower requirements data directly from the operational plans. Also more detail by occupation was desired at the local level. (These concerns were similar to those found in other Navy personnel modeling studies (see Niehaus (1979, Ch 5)).

NAVSEA shipyard management has decided to concentrate model development efforts in the near term at the headquarters level. Particular attention will be paid to the development of the manpower requirements data consistent with shipyard loading as

20

determined by the ship overhaul schedule. The continued use of the models is to be paralleled by a study of the best ways to bring together existing management practices with a more comprehensive implementation. The individual shipyards will continue to be appraised of model results as they are used to develop the overall corporate plan for all the shipyards. In the longer term, efforts will be made to extend the model technology to the local level. In summary, it is planned to continue to use the models as a tracking and evaluation vehicle. Briefings and training for a wider group of NAVSEA personnel are planned as the technology gains acceptance. With the continued strong support of NAVSEA's top management, it is anticipated that the flow modeling technology will eventually be integrated into the strategic and operational planning accomplished in the management of the naval shipyards.

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